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ECOLOGY

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LIFE HISTORY AND ECOLOGY OF THE PIGMY SUNFISH, ELASSOMA ZONATUM

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In the prosecution of studies of the relation of fish to mosquito control in the delta region of the Mississippi, observations were made on the pigmy sunfish, *Elassoma zonatum,* which serve to extend our knowledge of this smallest representative of the spiny-rayed fishes.

The writers were engaged as representatives of the United States Bureau of Fisheries which had entered into cooperation with the United States Bureau of Entomology, and the observations were made at the field laboratory of the latter Bureau, at Mound, Louisiana.[1]

Literature

The literature on the *Elassoma* genus, aside from publications on the distribution and taxonomy of its species, is very limited. *E. zonatum* was

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[1] We are indebted to Dr. W. V. King and Mr. Haw Kirkpatrick of the U. S. Bureau of Entomology, respectively, for the photo-micrographs used in this study and the pictures that appear herewith.

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originally described by Jordan[2] in 1877 from a specimen taken in the Little Red River, Arkansas, in a collection of Professor Henry S. Reynolds.

In 1884, the same author[3] gave a brief systematic description of *Elassoma zonatum* in the publication of a list of fishes collected near New Orleans by Dr. R. W. Shufeldt. In a list of fishes taken in Lake Jessup and Indian River, Florida, by R. E. Earll, Jordan[4] (1884) gives the original description of *E. evergladei*

A. J. Woolman[5] (1890) in a report on the indigenous fishes of central Florida mentions *E. evergladei* and gives a description of the species. Jordan and Evermann[6] (1896) give a systematic description of the two species of *Elassoma evergladei* and *zonatum,* and note their general distribution as follows:

E. evergladei.	"Georgia and Florida."
E. zonatum.	"So. Ill. to Texas; La. and Ala. Not very common and only in still waters of small extent, variable."

Dr. Einar Lönnberg[7] has published descriptive notes on an *Elassoma* found at Orlando, Florida, and named provisionally by him *E. orlandicum.* With the systematic description of the purticular fish he found he gave some cursory observations on its breeding season and eggs.

Dr. H. M. Smith[8] (1907) gives a key for the determination of the species of *Elassoma* and also discusses the distribution of *E. zonatum* in North Carolina. He notes that this species is found co-habitant with *Umbra* and various cyprinodonts (*Gambusia, Heterandria,* etc.).

Forbes and Richardson[9] (1908) published a systematic description of *E. zonatum* with a note on its occurrence in Illinois.

[2] Jordan, David S.: "Contributions to North American Ichthyology Based Primarily on the Collections of the U. S. National Museum," p. 50. Washington, 1877.

[3] Jordan, David S.: "List of Fishes Collected in the Vicinity of New Orleans by Dr. R. W. Shufeldt, U. S. A." Proceedings, U. S. National Museum, Vol. VII: pp. 318–322, Washington, 1884 (1885).

[4] Jordan, David S.: "List of Fishes Collected in Lake Jessup and Indian River, Florida, by R. E. Earll, with Descriptions of Two New Species." Proceedings, U. S. National Museum, Vol. VII: pp. 322–324. Washington, 1884 (1885).

[5] Woolman, Albert J.: "A Report on the Rivers of Central Florida Tributary to the Gulf of Mexico, with List of Fishes Inhabiting Them." Bulletin, U. S. Fish Commission, Vol. X: pp. 293–302, 1890 (1892).

[9] Jordan, David Starr, and Evermann, Barton Warren: "The Fishes of North and Middle America." Bulletin 47, U. S. National Museum, Vol. 1: p. 982. Washington, 1896 (1898).

[7] Lönnberg, Einar: "List of Fishes Observed and Collected in South-Florida." Öfversigt af Köngl. Vetenskap-Akademiens Förhandlingar, No. 3, pp. 109–131. Stockholm, 1894.

[8] Smith, Hugh M.: "The Fishes of North Carolina." North Carolina Geological and Economic Survey, Vol. II: p. 228. Raleigh, 1907.

[9] Forbes, Stephen Alfred, and Richardson, Robert Earl: "The Fishes of Illinois." Natural History Survey of Illinois, Vol. III: p. 232. Danville, 1908.

Dr. R. E. Coker[10] (1917) discusses the history of *Elassoma* and also gives a description of the species and its habits as observed in aquaria. He include a general description of the natural habitat of *E. zonatum* at Mound, Louisiana. The food habits of this species are mentioned with the question raised as to its probable value as an agent in mosquito larval control, in as much as he observed that it fed on entomostracans and mosquito larvae in aquaria. The hardiness of this little fish is indicated by the fact that seventy-five of them remained alive four days in a ten gallon milk can on an extended railroad trip. Dr. Coker used as an illustration the first published drawing of *E. zonatum*.

W. A. Poyser[11] (1919), an aquarist, describes the color patterns of male and female *E. zonatum* as he observed them in his aquarium. He mentions rapid changes in color patterns and in density of pigmentation which he understands as merely accompanying the spawning act. Observations in connection with the present study show that as the breeding season approaches the male and female become bluish black and pallid green, respectively, and remain so throughout the height of the breeding season which may last several weeks. As this season comes to its end the pigmentation gradually returns to normal, at which time the male and female again become hardly distinguishable by their color patterns.

Poyser accurately describes the spawning act, after having observed this twice in his aquarium. The eggs were laid, as he notes, at distances of seven and eleven inches from the bottom, fertilized as extruded, and sank to the floor of the aquarium, where they remained possibly protected from enemies by the male. No nest was prepared for the eggs.

Environment

In the vicinity of Mound, *Elassoma zonatum* was taken in only one small water system, which possessed a distinctive association of environmental features.

This habitat is Cypress Bayou (fig. 1), a typical winding bayou and "wild" except at a few road-crossings. It extends through several miles of plantation and wooded country, its size and distribution fluctuating generally with the seasons of the year, since its sources of supply, seepage and rainfall, vary usually according to season. The bayou at one end meets the levee of the Mississippi River from which it derives its seepage water, and inasmuch as the river is usually at its highest stage during the late winter and spring months, the seepage is therefore greatest at that time. Rainfall, the other source, averages for this locality about fifty inches annually, with the greater part coming between October of one year and May of the next. As a result of the coincidence of the factors of supply, the bayou surface with all its ramifications, consisting of ditches and cross-bayous, is very much more extensive during the spring than at any other time. As the summer approaches and the sources of supply diminish, there is a consequent decrease in surface area and depth which continues until the following October. Even though much of the bayou dries, there always remains a considerable portion which at the lowest water stage measures at least five feet in depth.

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[10] Coker, Robert E.: "The Pigmy Sunfishes." Aquatic Life, Vol. III, No. 2, October, pp. 22–24. Philadelphia, 1917.

[11] Poyser, W. A.: "Notes on the Breeding Habits of the Pigmy Sunfish." Aquatic Life, Vol. IV, No. 5, pp. 65–69. Philadelphia, January, 1919.

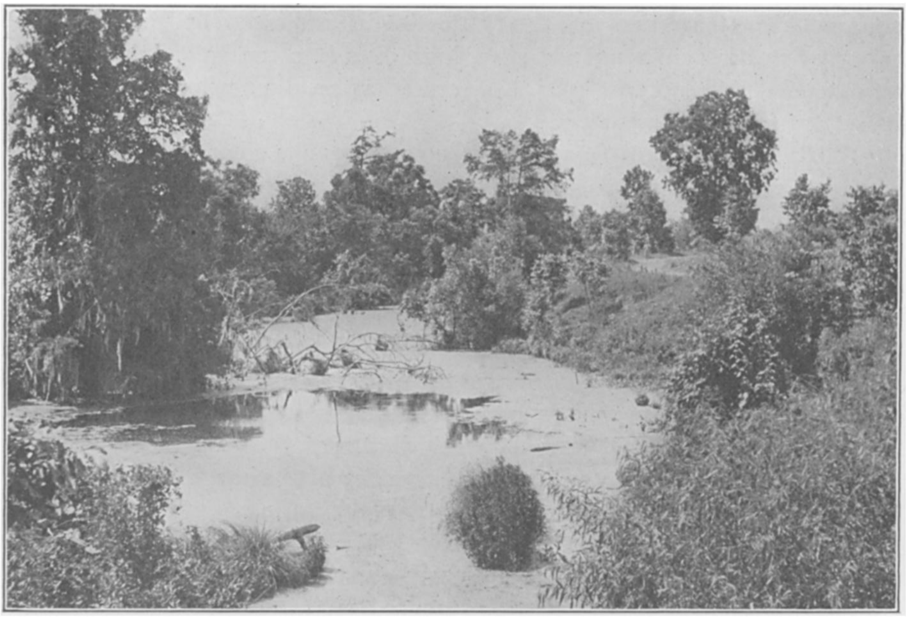

FIG. 1. Cypress Bayou, Mound, Louisiana; habitat of pigmy sunfish. Note the heavy mat of surface vegetation.

This section of the bayou which persists possesses to the most marked degree the environmental features which furnish the typical habitat of the pigmy sunfish. In this connection it is worthy of note that in all the many routine collections made for four years in certain ramifications and continuations of the bayou where the particular vegetative environmental features of the *Elassoma* habitat do not obtain, there has never been a single specimen of this species.

The outstanding floral characteristics of the *Elassoma* habitat at Mound are a heavy surface mat made up of *Lemna, Spirodela, Wolffia,* and *Azolla* in combinations varying seasonally, and beneath this mat a flourishing growth of *Ceratophyllum*. In the marginal waters where the surface growth is occasionally broken, filamentous algae are commonly found. From the annual deaths of the surface plants, resulting layers of decaying vegetation have covered the original bottom of delta mud to a considerable depth.

Co-habitant with *Elassoma* accidentally occurs *Gambusia,* which seeks out occasional open spots in the thick surface mat. *Fundulus henshalli, Amiatus calvus, Lepomis cyanellus,* and *Abramis chrysoleucas* are found also, but in very limited numbers. Early in the summer as the water depth decreases and the submerged vegetation is proportionately concentrated, the very physical nature of the *Elassoma* habitat makes it unsuitable for larger fish. In early spring during high water several other species have been found in this particular section of Cypress Bayou, some of them apparently breeding in these waters. Subsequent collections, however, reveal strikingly few individuals that might have come from these broods, a finding which demonstrates the unfavorable character of the *Elassoma* habitat for larger fish. Of the 351 fish taken in this portion of the bayou in the systematic biweekly collections of 1918 as a part of the mosquito larval control study, 339 or 97 percent were *Elassoma zonatum.* The nice adaptation of this species to its environment with the nearly total exclusion of other fish perhaps predacious on it very much enhances its possibility of survival.

The insect fauna of this particular habitat consists of the common aquatic forms, including representatives of the following: Belostomidae, Odonata, Dytiscidae, Notonectidae, Nepidae, and several dipterous families, especially the Stratiomyiidae and Chironomidae. Of these the Belostomidae and Odonata nymphs have been observed to be predators of the pigmy sunfish. Possibly others of the above list are likewise enemies of *Elassoma.*

In other sections of Cypress Bayou, representing entirely different associations of vegetative environmental features, both the insect and fish fauna stand in marked contrast to that discussed above. The number of species of fish and their relative frequency vary remarkably in different portions of the same bayou, and another bayou at not more than one half mile's distance has a fish fauna as characteristic as that of Cypress Bayou.

Description of Sexes.

The sexes in *Elassoma zonatum* are clearly differentiated, immediately before and during the breeding season, by the contrast in pattern and depth of pigmentation as observed in representatives of the two sexes taken at Mound (fig. 2). During three years of intermittent collecting in Cypress Bayou, no *Elassoma* had been taken either in a gravid condition or in a newly-hatched or very young stage until March 7, 1919, when several females whose abdominal parts were considerably distended were captured. Examination proved these fish to be gravid. That no gravid *Elassoma* had been taken in the bayou formerly was due to the fact that collections had never been made earlier than the latter part of April.

The female at the breeding period is of a decidedly light color compared to its appearance at other seasons. As it reaches a very ripe condition the vertical lateral bands, so characteristic of both sexes after the breeding season, almost entirely disappear, only a faint suggestion remaining. In life, the fish in general presents a light olive green appearance, there being a very noticeable reduction in lustre and contrast in the usually spotted and banded pigmentation. Even the pigmentation of the fins disappears. The pectoral, ventral, and anal fins are so colorless that when spread in their natural swimming position in the water they are transparent. The many small dorsal and caudal fin spots are very faint. The ordinary greenish metallic sheen of the opercle is lacking, while the head, with special reference to the lower jaw and isthmus, is entirely unspotted. The light pigmentation of the opercular region makes the bright red of the gills very evident through the translucent tissue of the opercular plates. The gravid female belly, swollen with ripe and ripening eggs, is rather long and oval in shape, quite different from the roundness of the gravid *Gambusia* belly. As the breeding season passes, the female color pattern darkens, the darkening beginning below the lateral line and extending upward until the usual banded condition similar to that of the male is reached.

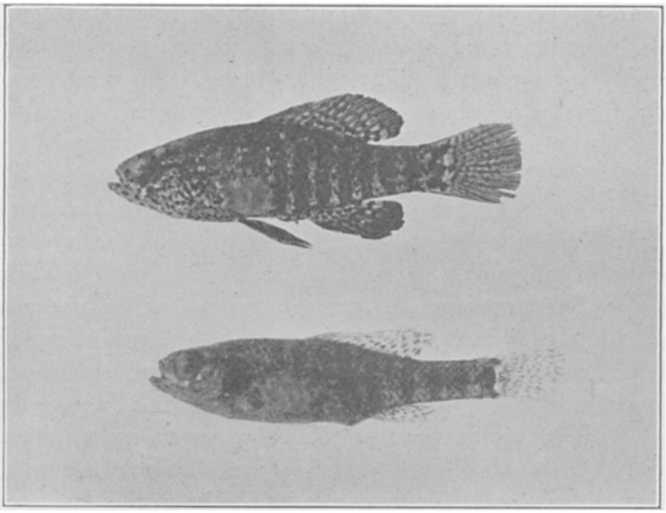

FIG. 2. Male (upper) and female *Elassoma zonatum* at the breeding season, × ¾.

Of the 273 gravid *Elassoma* females taken during the breeding season of 1919 the largest measured 3.5 cm. from tip of head to the base of the caudal fin; the smallest, 1.8 cm. The modal length for all was 2.5 cm.

The male *Elassoma zonatum* in breeding season is readily distinguishable because of the increase of the pigmentation and its brilliant intensity. The male has a greater depth of body than the female and presents a very sturdy appearance, with a slightly larger head and heavier jaws. The general color of the male in life during the breeding season is a very dark bluish black, contrasting distinctly with its very lightly pigmented vertical bars. The lower jaws and isthmus are punctulate with many small black pigment spots, in strong contrast to the bluish white tissue in which they are set. The post-opercular region is nearly black, glistening with a lustrous metallic sheen of bluish green. In life the vertical bands of blackish pigment are clearly discernible as far posterior as the beginning of the anal fin, while the color reaches distinctly to about one half the distance below the lateral line where it blends with the black spotting of the compressed belly; in preservative the diffuse pigment which makes the lateral bars indistinct in life disappears and the several black stripes are plainly evident as far as the caudal fin. The black chromatophores appear in uniform bands on the opercles and isthmus, with regular rows of these dots in the region of the mouth. The spots in the dorsal region of the head are indistinct owing to the heavier diffused black pigmentation of that region. The fins of the males are all very dark, slightly larger than those of the female, and are finely punctulate with rows of black points. The ventral fins are longer and jet black, tapering to fine black tips. The spots are more numerous, darker, and more distinct in this sex.

Of the 131 males taken during the breeding season of 1919 the largest was 3.0 cm. in length; the smallest was 1.8 cm. The modal size for all was 2.4 cm.

In seven collections taken on different days in March, 1919, there were obtained 404 *E. zonatum*. Of these, 273 or 67.5 percent were females; 131 or 32.5 percent were males. This indicates that in nature the numerical relation of male to female is approximately one to two.

In all descriptions of *E. zonatum* which have been at our command special mention is given of a black scapular blotch; yet only 3 of 128 adults examined from one collection in April, 1919, had this type color pattern distinctly evident. These observations indicate the variability of the species as regards this character and discredit its value as a species-determining mark. The large majority of the fish observed showed only a slight broadening and darkening of the first, and occasionally of the first and second pigmented vertical bars posterior to the gill openings.

Breeding Habits

The breeding season for the pigmy sunfish begins in northern Louisiana about the middle of March. The first larvae of this species were taken on March 25th and the largest and most developed of these showed complete yolk absorption. This would indicate, from data already collected on the larval growth of *E. zonatum* and hereafter noted, that the eggs from which these fry hatched were laid at least by March 15th. The number of eggs laid by a female may be indicated by the table below. The figures give the number of ova taken from preserved gravid females captured near the beginning of the breeding period, March 25th. The ova thus studied would have been laid later in the season.

MARCH 25, 1919

Number of Female *Elassoma zonatum*	Number of Eggs Present
2.25 cm.	96 eggs.
2.35 "	325 "
2.4 "	175 "
2.6 "	310 "
2.65 "	260 "
2.9 "	500 "
3.2 "	575 "
3.5 "	970 "

Some of the above recorded fish may have released a small number of their eggs, and this doubtless accounts for any disparity in the general relation between size of female and number of ova.

The following tabulation was made of ova counted from fish taken April 25th, when by far the greater part of spawning had already occurred. The fish examined must have been rather late in ripening. Comparison of the number of ova present on the two dates, however, indicates that spawning is intermittent throughout the extent of the breeding season.

APRIL 25, 1919

Length of Female *Elassoma zonatum*	Number of Eggs Present
2.45 cm.	145 eggs.
2.6 "	236 "
2.6 "	150 "
2.5 "	200 "

The eggs are laid in quantities of forty to sixty in places protected by submerged vegetation. They are found scattered and covered with tiny bits of plant débris and silt. Occasionally some developing eggs were taken from among the strands of *Ceratophyllum* which had probably obstructed the falling of the eggs from the mother fish to the bottom. The ova require no care, as many artificially impregnated eggs that were left without attention in pans both in the natural habitat and in the laboratory showed normal development.

The spawning is repeated as a new batch of ova becomes mature, at intervals of approximately a week's time. All females taken during March were heavily gravid, about ten percent. of these carrying ripe spawn; while apparently all male fish were ripe, as fertilization occurred in all eggs where artificial impregnation was attempted. The water from which these fish were taken was somewhat warmer than in other parts of the bayou owing to the fact that recent heavy rains had swept away the surface mat of vegetation from this particular collecting spot. In parts of the bayou where the surface mat remained intact the water registered 57° F. at all times during collecting; while at the above mentioned clear space, where the sun could beat directly into the water with no obstructing vegetation, the temperature varied between 62° and 68° F. No ripe females were taken from the colder waters, and apparently the temperature was the determining factor that led the ripe fish to seek the open-surfaced area. The eggs are laid at a depth of from six inches to two feet, judging from the locations from which they were collected in our plankton nets.

That *Elassoma zonatum* after breeding seeks a different location, doubtless in deeper or cooler water, is indicated forcibly by the fact that on April 7th, in two hauls of a twelve-foot minnow seine, 128 adult *Elassoma* were taken, while on the 25th of April, in three hauls, only the four females above recorded and two adult males were obtained. This probable migration of *E. zonatum* after spawning is further borne out by the fact that in the biweekly collections of 1918 at this collecting ground not a single adult was captured that could have been from a brood hatched previous to the spring of 1918.

The eggs are spherical and measure .5 mm. in diameter. They are orange colored, semi-opaque, and contain one large oil globule measuring .15 mm. in diameter and many appreciably smaller ones. The large oil globule persists throughout the entire embryonic and larval stages until the yolk is absorbed. The eggs are demersal and slightly glutinous, as is evidenced by the fact that they occasionally cling to submerged vegetation. Often temporary concavities are observed in the ova, the result of mutual compression as they lie in the ovary prior to spawning. The ova water-harden quickly, the egg membrane measuring .2 mm. in diameter. This tissue is especially tough, an adaptation to the physical surroundings during the embryonic development of the egg. The ova can be stripped or cut from the ripe female *Elassoma* and readily fertilized by placing them in a receptacle with the macerated testes of a male. The incubation period of *Elassoma* eggs at 65° is approximately seven days.

EMBRYOLOGY

Immediately after impregnation the relatively small amount of protoplasm of the egg collects in a lenticular cap-like mass, the blastodisc. This is formed in about an hour and one half at 65°, and the several beginning stages of segmentation occur rapidly after the disc has developed until it encloses about one third the surface area of the ovum. At an early embryonic stage in which the outline of the broadening head and the rudiments of the tapering tail are just beginning to appear, slight pigmentation of the embryo is observed. The small chromatophores are not limited to the embryo proper but appear also on the extra-embryonic tissue surrounding the yolk. As growth continues the pigmentation is much more evident. On the sixth day when the embryo is nearly ready to hatch, the pigmentation extends over the entire body and the tissue about the yolk. The tail is wrapped closely about the yolk overlapping the lower head region.

Larval Development

At the period of hatching the small larva measuring 2.7 mm. long wriggles actively forth from the protecting membrane. The larva remains quiet for the most part resting on its side on the bottom but giving occasional spasmodic swimming movements. From the beginning, as in the adult, the swimming is occasional but very swift. As the larvae develop they daily become more active.

The larva at birth is of a light straw color. The tissue is so transparent that the entire circulation can be easily observed. The newly-born fish is well pigmented, especially on the head and along the dorso-lateral region. The pigmentation extends noticeably down over the unabsorbed yolk-sac. There are several spots of yellow pigment distributed along the dorsal line and much diffuse yellow pigment on the frontal region.

Larval development is slow and for the first three or four days the noticeable developments include only a slight diminution of the yolk-sac, a little stronger black pigmentation, and thorough diffusion of all yellow chromatophores. The larva grows perhaps a millimeter in this period. During the fifth and sixth days the black pigmentation increases markedly on the upper yolk-sac. On the eighth and ninth days the jaws of the fish become quite distinct and the first evident approach toward fin differentiation is noticed. A typical larva at this stage measures slightly over 4 mm. On the fifteenth day the larva has taken on approximately the appearance of the adult. The jaws are fully formed, the yolk-sac absorbed, and the dark pigment somewhat diffused, giving the young fish nearly the likeness of the adult except for the lack of the pigmented striped color pattern of the fins and of the body. At this stage the little fish begins eating, taking bits of débris. It has been observed, however, that the stomach contents of several larval *Elassoma zonatum,* so young that their fins were not yet differentiated, consisted of small cladocerans. During the larval stages the fish is very hardy and has withstood in the laboratory changes of temperature of at least twenty degrees in the course of ten hours with no apparent ill effects. When the larva attains a length of 8.5 mm. it begins to show evidence of the presence of the vertical lateral bands typical of the adult.

GROWTH

During the period from May, 1918, to April, 1919, much information on the growth of the pigmy sunfish was collected. Within this time a total of 743 fish were taken in thirteen collections. Each collection had a sufficiently large number of *Elassoma* from which a fair modal length could be obtained. Each fish was measured and recorded and the modal length for all *Elassoma* in each collection was noted. From these data it is possible to construct a graph, figure 3, which very plainly indicates the growth of the little fish. It is suggested from this graph that the pigmy sunfish reaches its adult size and becomes sexually mature before it is a year old and, as our observations show and the graph indicates, at this age the fish will have produced a new brood.

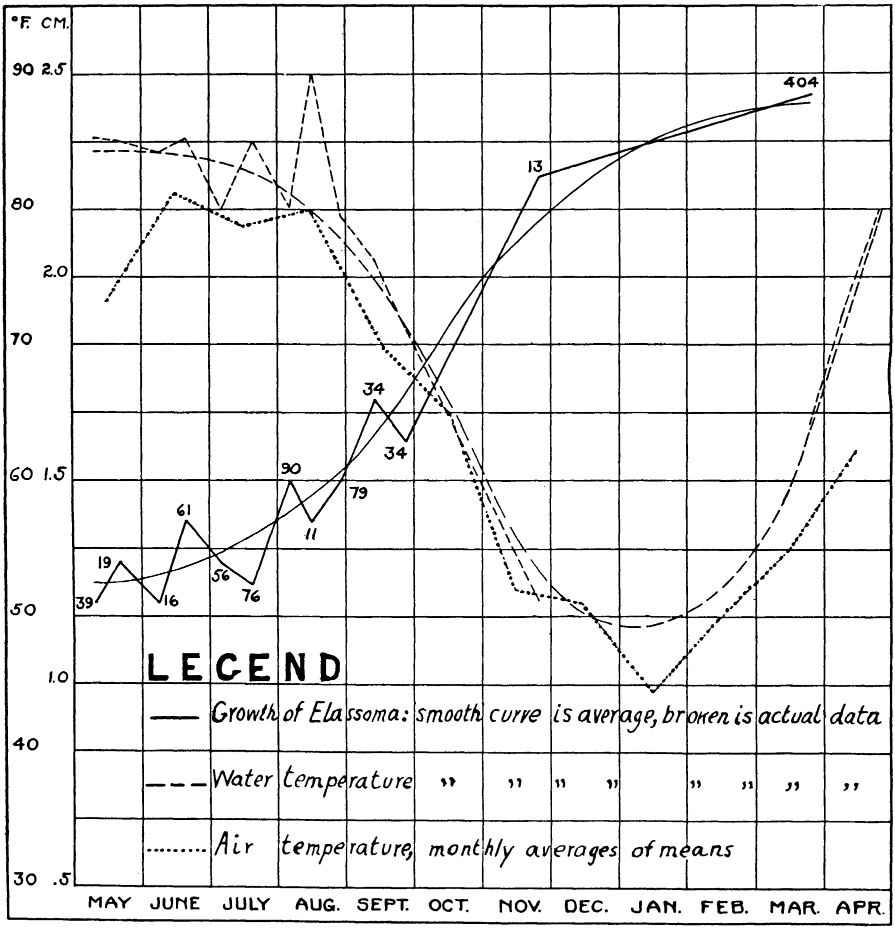

FIG. 3. The relation of the growth of *Elassoma zonatum* to season and temperature, for 1918.

The higher temperature which prevails during the summer months is of considerable significance in the study of *Elassoma* and, indeed, of all fish growth. First, it speeds up all physiological processes of the fish; simultaneously it quickens the photosynthesis of all plants—in this case especially *Ceratophyllum*—and the increased oxygen thus released by plant growth, in turn, serves to make the pool capable of supporting a larger number of oxygen-consuming forms—an automatic natural provision of a more healthful medium for fish life, plant life, and that of the smaller food organisms. In a word, the higher temperature means more fish food, more efficiency in its utilization, and a greater capacity for the pool in supporting fish life.

It is noticeable, also, in the graph that the temperature of the water, the medium in which all changes in plant and animal life occur to affect fish, varies almost regularly throughout the year with the changes in air temperature as indicated by the monthly average mean temperatures. Water temperatures, as indicated in the graph, were plotted by computing the mean between the temperature at the maximum depth and that at the surface.

The comparative straightening of the mean growth curve during the period from November to March of the succeeding year suggests the lowering in rate of metabolism during the winter months common to all cold-blooded animals, as caused by and coincident with the decrease in temperature of the water medium. Not only does this lowering of temperature thus influence the growth of the fish directly, but also indirectly through its effect upon the maturing, reproduction, and consequent abundance of those organisms which serve as fish food.

Realizing that during the summer and fall of 1918 Cypress Bayou had held a minimum of water, due to continued drought, and surmising that the relatively higher temperature of the water necessarily resulting from this drought might have had some effect on the growth of *Elassoma,* it was decided, in view of the fact that the data could be collected simultaneously with other material, that further similar observations on growth should be made during 1919. Fortunately the spring, summer, and fall of 1919 were of about normal rainfall and temperature, thus giving much data that might be well contrasted with the 1918 observations. These 1919 data gave a curve the general direction and shape of which is the same as that of 1918; however, it is about .2 cm. behind the 1918 curve at any chosen period of the year. This comparative tardiness in the growth of 1919 is due probably to the cooling effect that heavy rains and consequent greater depth had on the water in which *Elassoma* thrived. The concavity in the curve, though not characteristic of typical fish growth, seems to be normal for the development of *Elassoma* to full size.

Among the biweekly collections at the *Elassoma* habitat, beginning May 9, 1918, no adult pigmy sunfish over two centimeters long were taken until in November. All the catches were plainly of fish of the 1918 spring hatch.

It is remarkable that among the 267 *E. zonatum* taken before July 18th, there never appeared an adult, *i.e.*, one that had been sexually mature in the spring. It may be that the adults after producing their brood seek such deep and inaccessible waters that they were not obtained in the biweekly collections, although no information on this point is at present available. This seems to be borne out, however, from a study of the scales of certain of the largest fish collected during the early winter and spring. The scales of several of these fish indicated that they were about to complete their second year of life. The largest male taken in this study, 3.4 cm. in length, was in its third year.

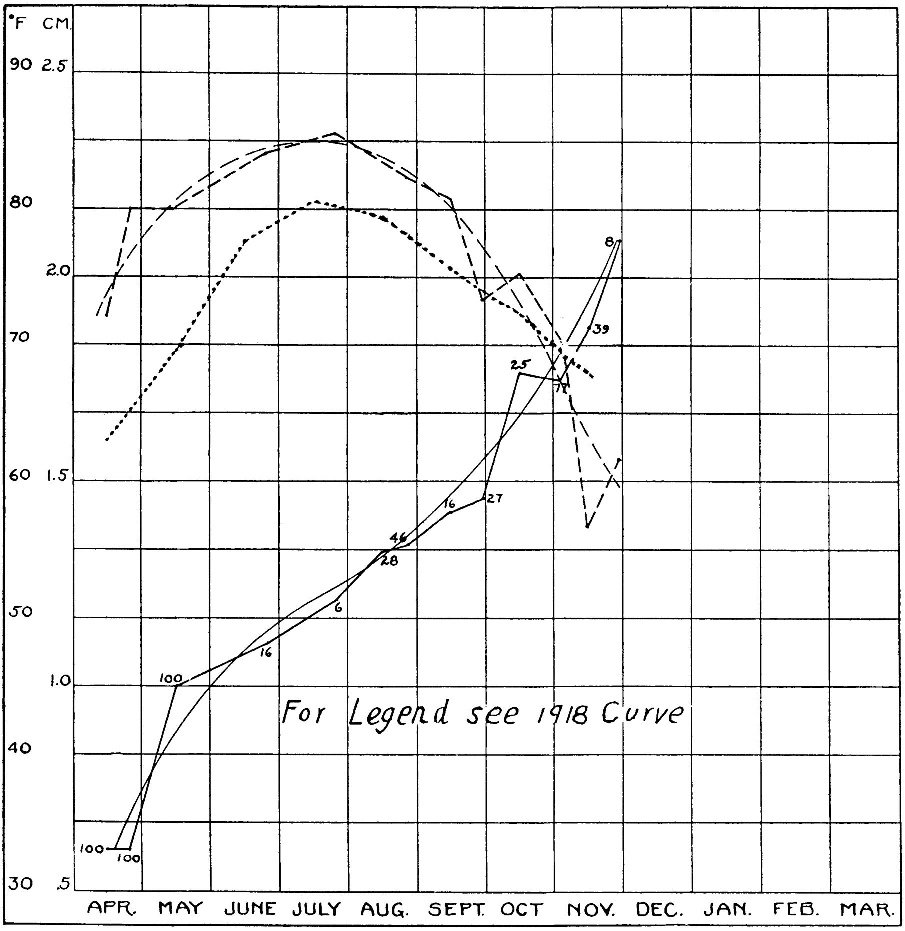

FIG. 4. The relation of the growth of *Elassoma zonatum* to season and temperature, for 1919.

STOMACH CONTENTS OF ELASSOMA ZONATUM

(Estimated Volumetric Percentage of Different Foods)

Period during which collected	No. of fish examined	Length in cm.	Crustaceans					Insects							Mollusks (Univalve)	Plants (Algal spores)
			Copepods	Cladocera	Ostracoda	Malacostraca	Total Crustacea	Chironomidae L. & P.	Stratiomyiidae	Dipterous undetermined	Coleoptera	Odonata	nsecta undetermined	Total Insecta		
May 9, to Nov. 29, 1918.....	46	1.1 to 2.9	27.2	27.5	4.2	2.8	61.7	32.2	2.1	.2	.9	.8	2.0	38.2	0	.8
Mar. 7, to Mar. 31, 1918.....	26	2.3 to 3.25	25.0	35.0	10.8	7.7	78.5	0.	5.2	1.8	.0	.0	1.1	8.1	10.9	2.1
May, 1918 to Apr., 1919.....	72	1.1 to 3.25	25.8	29.8	6.6	4.5	66.7	20.5	3.2	.88	.62	.52	1.8	27.4	3.9	1.3

FOOD

A few fish of each of the biweekly collections of 1918, constituting in all 46 individuals, and 26 of the spawning adults taken in March, 1919, were examined to ascertain the character of food taken by *Elassoma* in nature. Determinations of the animal and plant life found in each stomach were made, and an approximate volumetric percentage of the different organisms present was recorded. These are herewith summarized.

From examination of the foregoing figures it will be noted that the small crustaceans constitute the major part of *Elassoma* food at all ages of the fish from two months through maturity. The aquatic larvae and pupae of several dipterous families, especially *Chironomidae,* are next in quantity. That there was only a small percentage of insect food in the adults' stomachs at breeding time is probably due to the fact that the insect fauna may have been less abundant at that time and, also, that snail eggs were hatching in great numbers on the strands of the submerged *Ceratophyllum.* It will be noted that these univalve mollusks constitute a tenth of the breeding *Elassoma* food.

It is worthy of notice also that vegetation makes up a negligibly small percentage of *Elassoma* food at all seasons of the year. The only plant forms found in the seventy-two fish examined were algal spores, probably motile or accidentally ingested with other food. It is also noteworthy that no fish of any kind was found in any of the stomach contents. This fact is a fair indication that this species is neither cannibalistic in nature nor predacious on other fish forms, especially since there were thousands of larval pigmy sunfish in the collecting place that doubtless made themselves noticeable by their spasmodic swimmings. It is hardly reasonable to think that the pigmy sunfish is predacious on *Gambusia* to any appreciable extent, even if the tendency were toward this, for it would be physically impossible for an *Elassoma* to devour a *Gambusia* unless the latter had lately been born. It is a significant fact in this connection that the natural habitat of *Elassoma* is such that *Gambusia* is absent therefrom, especially because of the latter's choice of open water spots unprotected from the sun. The two species would not be rivals for the same environmental area.

From the very nature of the food of *Elassoma,* in that it consists almost entirely of actively swimming or wriggling organisms—cladocerans, copepods, and chironomid larvae and pupae—it is very probable that this fish could be a valuable agent in mosquito larval control, if it thrived in waters where mosquito larvae were abundant. In the *Elassoma* habitat at Mound a heavy surface mat of vegetation apparently precludes almost all mosquito breeding with the exception of that of one species of *Culex* which is commonly found in such pools. In spring, however, before this mat has become thickly grown and while there still remain many small open spots suitable for mosquito deposition, these fish may be more or less of a natural control on anopheline mosquitoes.

ENEMIES

Elassoma in its natural hatitat at Mound has few competitors. It is true that should this fish wander from its home of thick submerged plant growth, it would quickly find numerous enemies among the fish. In its own environment, however, fish enemies are very few. Only occasional individuals of *Amiatus* work their way into the heavy *Ceratophyllum*. In its habitat snakes or fish-eating birds can do *Elassoma* a minimum of harm. Large water beetles, bugs, and Odonta nymphs are probably the only forms which the pigmy sunfish has to contend with.

SUMMARY

The occurrence of *Elassoma zonatum* appears to be closely co-related with a distinctive combination of environmental features. At Mound, Louisiana, it was found only in a typical "wild" bayou heavily grown with submerged *Ceratophyllum* and a thick surface mat of *Lemna, Wolffia,* and *Spirodela*. The nice adaptation of the species to its environment, and nearly total exclusion of other fish, much enhance its possibility of survival. It is hardy, both in its larval and adult stages.

The contrasting color patterns and the differing pigmentation of male and female *E. zonatum* immediately before and during the breeding season serve as means of distinguishing the sexes.

The breeding season of *E. zonatum* in northern Louisiana begins about the middle of March and lasts until about the first of May. The temperature of the water appears to be the factor determining the place where the eggs are laid. Under the mat of vegetation the water was 57° F., while the open water varied from 62° to 68° F.; gravid females and eggs were taken only in the warmer water.

An average-sized female may lay three hundred or more eggs, which are dropped at intervals of several days in lots of from forty to sixty. No nest is prepared. The eggs pass through a normal embryonic development and hatch in approximately seven days. After breeding, the fish seeks cooler and deeper water.

Growth is rapid in the larval and young stages. Curves of temperature (air and water) and rate of growth show that growth is more rapid when the water is warm and is retarded as the adult stage is reached and the water becomes cooler in November and December. The fish produces its first offspring when just a year old.

The food of *E. zonatum* consists principally of small crustaceans, larval and pupal aquatic insects, and small mollusks in some seasons. The size and habitat of *E. zonatum*, and the very nature of its food, make it very probable that under some conditions this species may be more or less of a natural control of *Anopheles* mosquitoes.

The larger aquatic insect forms, both larval and adult, rather than fishes, are probably the most destructive enemies of *E. zonatum* in its native habitat.